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Reproduction of Upland Hardwoods in Southeastern Ohio

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CENTRAL STATES FOREST EXPERIMENT STATION - W. G. McGINNIES, DIRECTOR

THE AUTHORS

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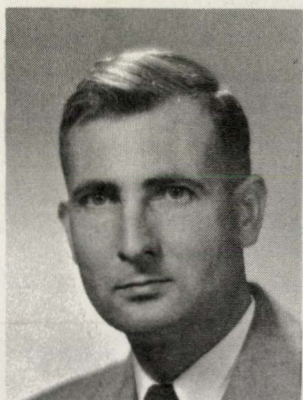
DR. STEPHEN G. BOYCE is a newcomer to the Station. In 1954 he began working part time at the Athens Research Center in southeastern Ohio. In 1957 he became a full-time staff member and was transferred to the Carbondale Center as project leader in regeneration and genetics. Steve got his training at North Carolina State College where he earned bachelor and master degrees in forestry and a doctorate in plant ecology. Before coming to the Station, he taught biology and botany at Meredith College, North Carolina State College, and Ohio University. Boyce has authored or co-authored 14 technical and scientific publications.

CONTENTS

A study of the reproduction in some cut-over areas in southeastern Ohio showed that the number and distribution of some hardwood species were affected by the degree of cutting and the composition of the original stand. However, topography and aspect did not affect the number and distribution of most species on the areas studied.

Cuttings in hardwood stands usually result in the establishment of both wanted and unwanted species. It is often possible to modify cutting practices to favor the establishment of certain species if seed sources are available. This observational study was made to find the species, number, and distribution of reproduction that were associated with the three degrees of cutting.

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DESCRIPTION OF AREA

The Vinton Furnace Experimental Forest is second growth and developed following extensive charcoal-wood cuttings made 90 or more years ago. The overstory is essentially even-aged and is of both sprout and seedling origin. White[1]; chestnut, and black oaks, and shagbark, bitternut, and pignut hickories are most abundant with yellow-poplar, scarlet oak, post oak, northern red oak, red maple, sassafras, dogwood, and sourwood as associates. A few blackgum, bigtooth aspen, black cherry, American elm, and white ash also occur.

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[1] Common names of trees according to Little (2).

The best sites are found on the lower slopes and in the coves, and north-facing slopes usually are better sites than south-facing slopes. Narrow ridges are commonly the least productive sites. In the study area the relief between ridges and coves is approximately 100 feet.

THE STUDY

Three 5-acre blocks were selected for study. On one block all trees taller than 4.5 feet had been cut; on another block, two-thirds of the basal area had been removed by cutting all trees having a merchantable 8-foot sawlog with a 10-inch or larger top; and, on the other block, one-third of the basal area had been removed by a selective cut (table 1).[2] On the heavily cut block, 92 percent of the trees larger than 12 inches d.b.h. were cut while on the lightly cut block only 37 percent of trees this size were cut (table 2).

Each block was isolated from adjoining blocks by a 1-chain strip treated in the same way as the block. The partial cuttings were made in the summer and early fall of 1953; the clear cut was made during the winter, spring, and early summer of 1953-54.

METHODS

Reproduction studies were made in July 1955. Each block was divided into fifty 1-chain-square plots. Two randomly located milacre quadrats were examined in each of the 50 plots. Thus, a total of 100 quadrats were examined in each 5-acre block. Methods for sampling each quadrat and the statistical significance of differences observed are given in the Appendix.

Investigation revealed that only 12 percent of the oaks in the reproduction class originated after cutting. An additional 11 percent had tops that would lead a casual observer to believe they originated since the cut was made, but these oaks had roots that ranged in age from 3 to 27 years (4).

Thus, the data indicate the frequencies and densities of oak reproduction present at the time the plots were examined and do not imply this reproduction necessarily became established as a result of the cutting treatments. This was probably also true for the hickories, maples, beech, elm, and ash. However, 99.9 percent of the yellow-poplar reproduction reported here were seedlings that became established after the cuttings.

2/ All tables appear in the Appendix beginning on page 14.

RESULTS AND DISCUSSION

Reproduction after Clear Cutting

The total reproduction was most uniformly distributed on the area that was clear cut (fig. 1). Yellow-poplar reproduction was more abundant in the clear-cut block than in the partially cut blocks (table 3). In the clear-cut block there were 6,340 yellow-poplars per acre and they occurred in 87 percent of the quadrats (table 4). Furthermore, 55 percent of all reproduction found was yellow-poplar (table 5). All species of oak reproduction totaled 2,960 stems per acre with one or more oaks in 79 percent of the quadrats. Oaks constituted 25 percent of the total reproduction but made up 67 percent of the original stand. Reproduction of "other" species--including hickories, red maple, sugar maple, black cherry, beech, black locust, bigtooth aspen, American elm, white ash, and black-gum--numbered 2,270 per acre and constituted 20 percent of the total.

This block contained an abundance of yellow-poplar seedlings despite the fact that this species was a relatively minor constituent in the stands prior to cutting (table 5). These results, however, are consistent with observations made by McCarthy (3) who states that under certain conditions good yellow-poplar reproduction often follows clear cutting of old-growth stands containing some seed trees.

Figure 1.--Reproduction on north-facing slope of clear-cut plot.

Tree seedlings, shrubs, herbs, vines, and obstructions covered about 88 percent of the clear-cut block (table 6) which was greater than in the partially cut stands. Nearly half the area was covered with herbaceous plants and vines which was at least 60 percent greater than in the partially cut blocks (figs. 2 and 3). Grape was an important competing plant at the time the study was made. Patches of grape often formed dense shade and overtopped many seedlings and sprouts (fig. 4). However, there were more than 9,000 oaks and yellow-poplars per acre which seems sufficient to insure a well-stocked stand even though large numbers may be lost through competition.

The cover of oaks in the clear-cut block was about 1/4 of that in the partially cut blocks and the cover of yellow-poplar was very low in all blocks. The cover of these species was not related to their densities. For example, there were more than 6,000 yellow-poplars per acre in the clear-cut blocks but they covered less than 1 percent of the area.

In the clear-cut block there exists the potential for developing stands of: (1) Principally yellow-poplar; (2) mixed hardwoods consisting of yellow-poplar, oaks, and other species; or (3) principally oaks. It is not known what cultural practices would be needed to assure stands of the above compositions. However, with no further treatment, a mixed hardwood stand consisting mainly of oaks and yellow-poplar will probably result. To obtain a pure stand of yellow-poplar would undoubtedly require several cleaning and release cuttings.

Reproduction after Heavy Cutting

The heavily cut block had less than half as much yellow-poplar reproduction per acre as the clear-cut plot (table 3). Even so, 60 percent of the quadrats had one or more yellow-poplar seedlings, which made up 31 percent of the total reproduction (fig. 5). This was a marked change from the original stand where yellow-poplar made up only 1 percent of the trees (table 5). There was almost twice as much oak reproduction in this block (5,140 per acre) as in the clear-cut block and at least one oak was found in 95 percent of the quadrats. The oaks constituted 53 percent of the total tree reproduction, more than twice the percentage they attained in the clear-cut block. Other less important species made up the remaining 16 percent.

Figure 2 (right).--One-year-old yellow-poplar seedling and competing vegetation. Most of the surrounding and overtopping vegetation is herbaceous.
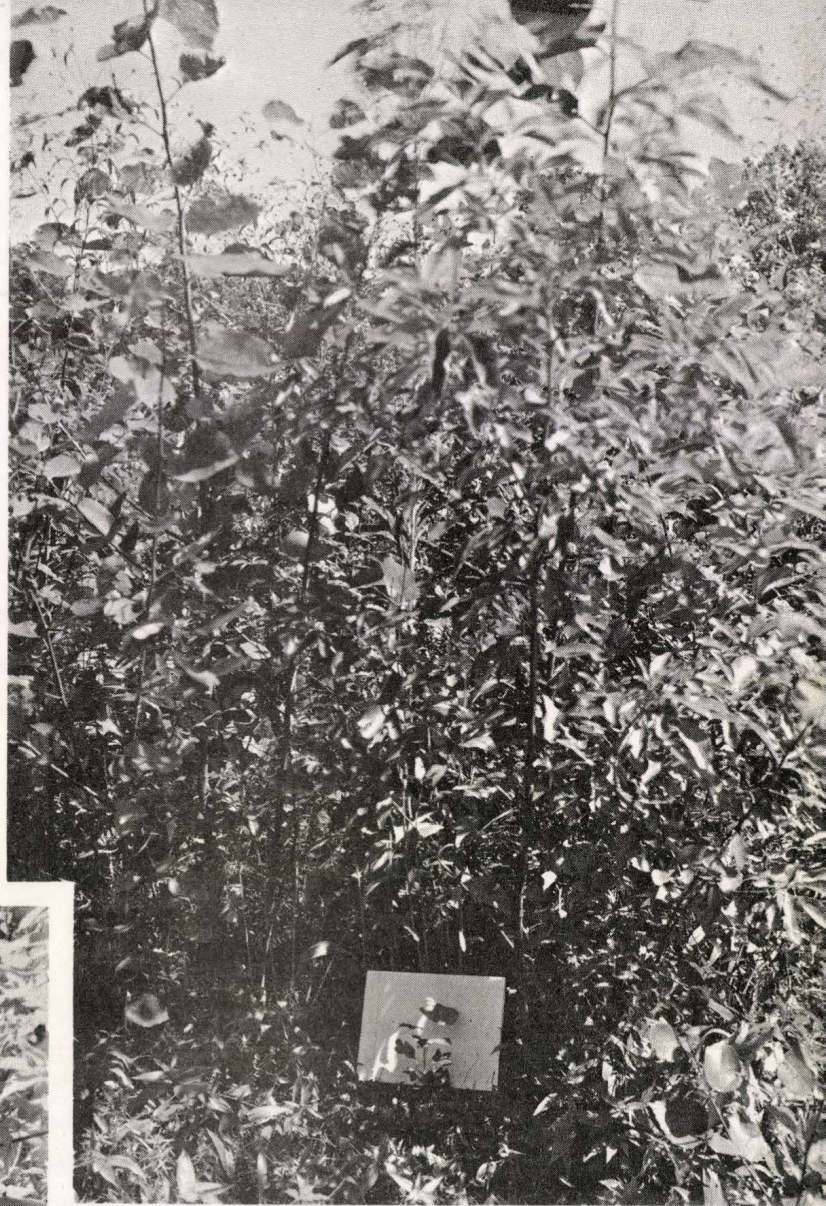

Figure 3 (left).--Yellow-poplar reproduction following clear cutting. At least three first-year seedlings more than 1 foot tall are visible.

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Figure 4 (right).--A dense growth of grapevines on the clear-cut plot.

Figure 5 (left).--Yellow-poplar reproduction competing successfully with dense sumac where a heavy cut was made.

The cover occupied by oaks was four times what it was in the clear-cut block (table 6). Conversely, cover from herbaceous plants, vines, and obstructions was much less than in the clear-cut block. The area unoccupied by plants at the time of examination, and classed as "open," was somewhat higher than in the clear-cut block.

After cutting, this block was a mosaic of conditions ranging from areas heavily shaded by remaining overstory trees to openings completely void of an overstory (fig. 6). Because the trees were selected for cutting on the basis of merchantability and size, the heaviest cuts were made on the best sites where the trees were largest. As a result the lower and middle north slopes, where most of the trees were large enough to be merchantable, were virtually clear cut. On the balance of the block the cutting was more selective and individual or small groups of trees were cut that created openings of various sizes. The heaviest residual stand was on the ridge where many of the trees were smaller than sawlog size. Residual chestnut oaks were numerous on the ridge, and the few residual yellow-poplars were located on the lower, south-facing slope.

Figure 6.--Heavily cut plot. In foreground is lower north slope that was almost clear cut. Residual stand of chestnut oak on upper slope and ridge may be seen in center of photo.

The distribution of yellow-poplar seedlings reflected the mosaic pattern of cutting described above. They were most abundant where conditions approached clear cutting and least abundant where there were no openings. Yellow-poplar became established in the large openings at about the same rate as in the clear-cut block; thus substantiating the evidence that openings of 1/4 acre or larger must be created to favor this species.

In contrast to yellow-poplar in this block, oak reproduction was more abundant where the least cutting was done. Much of the oak reproduction was found in the residual chestnut oak stand on the ridge.

On the basis of the reproduction present when this study was made, it seems possible to convert the lower north-facing slopes to pure yellow-poplar stands. But without cleanings and release cuttings, a stand of oaks and other species, as well as yellow-poplar would result. In the remaining area a mixed hard-wood stand would also result, except that yellow-poplar would be very infrequent.

Reproduction after Light Cutting

The light cutting was more favorable for the oaks than for yellow-poplar. In the lightly cut stand (one-third of the basal area removed) yellow-poplars were found on 47 percent of the quad-rats (table 4). There was an average of 1,180 yellow-poplars per acre (table 3) which constituted only 9 percent of the total re-production (table 5). In contrast, there were 9,310 oak stems per acre and they were found in 96 percent of the quadrats. The oaks constituted 73 percent of all reproduction. Species other than yellow-poplar and oak had a density of 2,290 per acre and occurred on 78 percent of the quadrats.

The "open" area was greater in this block than where the heavier cuts were made (table 6). This was because fewer herba-ceous plants and vines developed under the shade of the trees that remained.

The openings resulting from cutting were seldom larger than 1/10 acre and were well distributed as would be expected where several criteria for cutting were used (fig. 7). As in the heavily cut block, more yellow-poplar reproduction was found in openings than under the overstory. Probably the reason there were fewer seedlings of this species and limited distribution was because the openings created by cutting were small. Oak seedlings, however, were present throughout the plot as is evidenced by their high frequency (table 4).

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Figure 7.--Typical condi-
tions within lightly
cut plot. Note stump
in foreground where
tree was cut. Similar
opening can be seen in
right background.
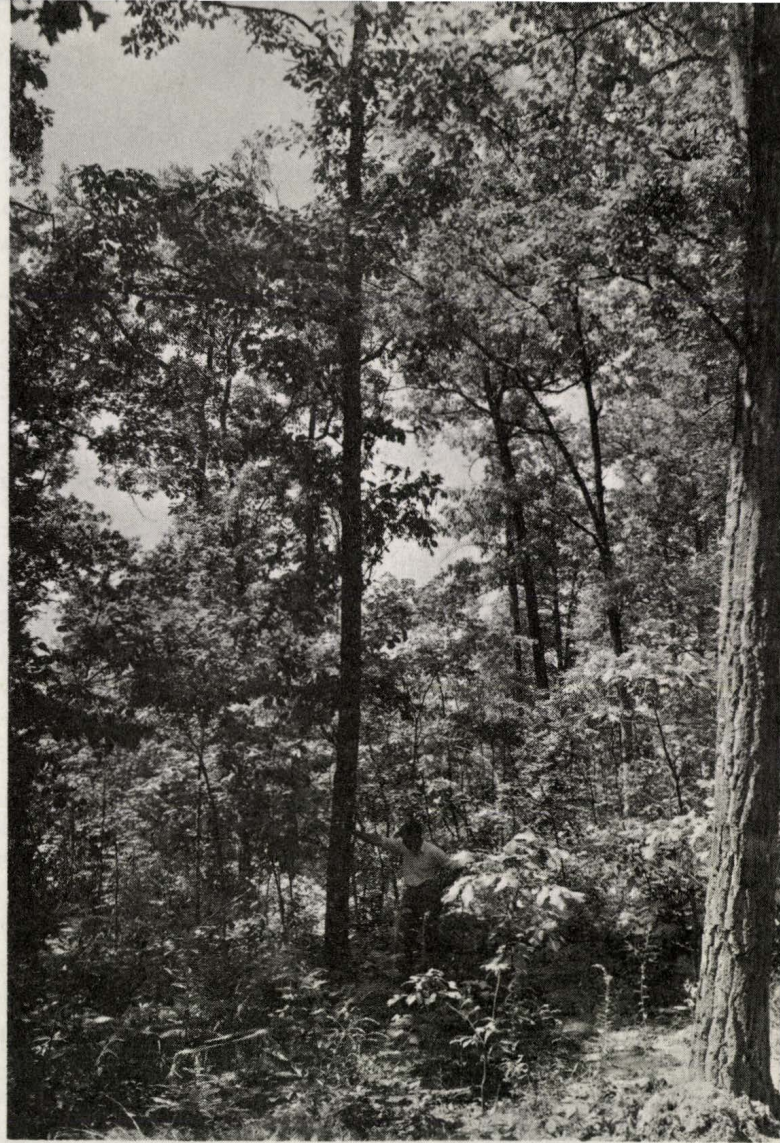
It seems certain that cuttings of this type favor the oaks,
and not yellow-poplar.

Effects of Topography on Frequency and Density of Reproduction

Density of reproduction was unrelated to slope position in
the clear-cut block except for yellow-poplar which was more abund-
ant on the lower slope (table 3). Where the heavy cut was made,
density of yellow-poplar was related to slope position and to de-
gree of cutting to a highly significant degree. Here the stocking
increased from 750 stems per acre on the ridge site to more than
10 times this amount on the lower slope. On the basis of evidence
from the clear-cut block it seems quite obvious that this was a
result of the heavier cutting that took place on the lower slopes
rather than to direct effects of topography. The density of oak
reproduction was also related to slope position and degree of cut-
ting. On lower slopes the density was significantly less than the
block averages.

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In the lightly cut block yellow-poplar reproduction was rather uniform in density except for the middle slope where the density was below average. This was probably a chance result and should not be attributed to unique conditions associated with middle slopes as such. Density of oak reproduction was greater on the ridges and less on the lower slopes than on the block as a whole. Since the oak reproduction included many seedling sprouts with old root systems, their distribution was affected by conditions existing before cutting. The high density on the ridge was also due to the large number of chestnut oak seedlings found on the ridge of this block.

Reproduction of "other" species showed significantly greater densities on the middle and lower slopes than on the upper slopes and ridges. Because there were indications of a similar trend in the other two blocks, it was believed that this difference was due more to the location of seed trees of the "other" species than topographic position.

There were no significant differences in frequency of reproduction among topographic positions for the three degrees of cutting (table 4). In the clear-cut block 80 percent or more of every quadrat examined, regardless of slope position, contained at least one yellow-poplar. On the partially cut blocks, yellow-poplars were more frequent on some topographic positions, but these were areas where larger openings occurred.

Regardless of slope position and degree of cutting, at least one oak was found in 64 percent or more of the quadrats. For the partially cut blocks the frequency was not less than 75 percent.

The frequency of species other than yellow-poplar or oaks was not related to slope position and appeared to be independent of the frequency of the yellow-poplar and oaks. When all the species are taken together, there was no slope position among blocks where the frequency of reproduction fell below 98 percent (table 6).

Thus, degree of cutting had more affect on the density and frequency of reproduction among slope positions than topography. Had topography been important, differences in densities and frequencies would have been most apparent in the clear-cut block.

Effects of Aspect on the Density and Frequency of Reproduction

On the clear-cut and the lightly cut blocks the density and
frequency of yellow-poplar were not affected by aspect (tables 7
and 8). In contrast on the heavily cut block, the density and
frequency of yellow-poplar were much higher on the north-facing
slope than on the south-facing slope. However, since cutting was
uniformly distributed over the clear-cut and lightly cut blocks
and was unequally distributed between the north and south aspects
of the heavily cut block, it must be concluded that degree of
cutting had a greater affect on the density and frequency of
yellow-poplar than aspect.

The density of oak reproduction was (1) lower than expected
on the south aspect of the clear-cut block, (2) not different from
the average on the heavily cut block, and (3) higher than the aver-
age on the south aspect of the lightly cut block. Because the oak
reproduction included seedlings, seedling-sprouts, and sprout clumps,
this distribution probably resulted from stand conditions existing
previous to cutting.

The frequencies of oak were high on both aspects of all
blocks. On the clear-cut block the frequency was slightly lower
on the south aspect than on the north aspect but was not different
between aspects for the other two blocks.

The density of "other" species was higher on the south as-
pect of the clear-cut block but was not different between aspects
for the other two blocks. The frequency of the "other" species
was relatively high on both aspects of all blocks indicating uni-
form occurrence.

APPLICATION OF RESULTS

This study shows that definite reproduction patterns can be
expected after cutting even-aged oak-hickory forests of south-
eastern Ohio. However, variations can be expected and should be
taken into consideration if the composition and basal area of the
overstory of a particular stand are greatly different from the
stands studied.

Light Cuts

When individual trees are selected for cutting and approximately one-third of the basal area is uniformly removed from a stand, oaks can be expected to make up most of the reproduction. Most of these oaks will be individuals established previous to cutting, they will be abundant, and they will be well distributed over the area.

Heavy Cuts

When all trees having a merchantable 8-foot sawlog with a 10-inch or larger top are cut and when the basal area is reduced by two-thirds, the reproduction can be expected to consist of a mixture of oaks and some yellow-poplar, if seed sources of the latter are present. Since this type of cut normally creates various-sized openings of unequal distribution, the reproduction will not be uniformly distributed. Oaks will be more abundant in and near the smaller openings and yellow-poplar will be more abundant in 1/4-acre-or-larger openings. This type of cut permits the least control over the distribution and abundance of reproduction.

Clear Cuts

When all trees taller than 4.5 feet are cut, yellow-poplar can be expected to make up most of the reproduction where there are seed sources. The yellow-poplar will be primarily seedlings established after the cutting; they will be very abundant and well distributed over the area.

Species other than Yellow-Poplar and Oaks

In all three degrees of cutting, hickories, red maple, sugar maple, black cherry, beech, elm, ash, and other tree reproduction can be expected to comprise about 20 percent of the total tree reproduction and to shade about 25 percent of the area. Hawthorne, hazelnut, huckleberry, blueberry, New Jersey tea, and sumac can be expected to shade 2 to 6 percent of the area. Neither clear cutting nor light cutting greatly changes the frequency or cover of these species.

After clear cutting, herbaceous plants and vines can be expected to shade 40 to 50 percent of the area. In partially cut stands these plants can be expected to shade 25 to 30 percent of the area.

Group-Selection Cutting

The advantages of both selection cutting and clear cutting can be combined by use of the group-selection system. Observations in this study and elsewhere indicate that small openings from 1/2 to 1 acre in size are adequate for the establishment of good reproduction. Furthermore, with the group-selection method of cutting, a source of seed for the openings and growing stock for future cuts are retained. If the openings are made near sources of yellow-poplar seed, a good stocking of this species along with oaks can be expected. In any case, oak reproduction probably will exceed 1,000 stems per acre.

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APPENDIX

Methods for Sampling Quadrats

For each quadrat all tree reproduction up to 4.5 feet in height and sprouts that obviously originated after cutting, regardless of height, were recorded by species and number. The distribution of quadrats by slope position and aspect are given in table 9.

The percent of each quadrat shaded by tree reproduction, shrubs, and herbs and vines was estimated.

The percent of each quadrat occupied by logs, limbs, stumps, and the bases of standing trees when they effectively reduced the area available for plant establishment was estimated. These were designated "obstructions."

The percent of area not occupied by any of the above and considered available for future plant establishment was estimated. This was recorded as "open area" even though these areas may have been shaded by residual overstory.

For each quadrat, these estimates were proportionately adjusted to give a total of 100 percent. The adjustments rarely exceeded 5 percent for any one category. Each plot was classified by north or south aspect and four topographic positions as follows:

Ridge.--The crest of the slope usually delimited by a distinct change in degree of slope,

Upper slope.--The upper one-third of the slope located immediately below the ridge,

Middle slope.--The middle one-third of the slope located immediately below the upper slope, and

Lower slope.--The lower one-third of the slope bounded on the lower side by a drainage channel and usually delimited on the upper side by a distinct change in degree of slope.

The Significance of Differences and Variation in This Study

The statistical significance of differences in density of reproduction among degrees of cutting for species or groups of species is summarized in table 10.

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Differences in density among blocks are highly significant for yellow-poplar and oaks, meaning that odds are one in 100 that differences are due to chance and not to degree of cutting. For the reproduction of other species the differences in density between the clear-cut and heavily cut blocks and between lightly and heavily cut blocks were also highly significant.

Table 1.--Basal area[1]/ per acre on the three blocks
before and after cutting

Cutting treatment	Basal area		
	Before cutting	After Cutting	Cut
	Square feet	Square feet	Percent
Clear cut	91	-	100
Heavily cut	86	32	63
Lightly cut	76	52	32

[1]/ The average total cross-sectional area per acre in square feet of all trees 3.6 inches or larger in diameter at breast height.

Table 2.--Stand density by species and diameter before and after cutting
(Number per acre)

Species and diameter (inches)	Clear cut		Heavily cut		Lightly cut	
	Before	After	Before	After	Before	After
Yellow-poplar						
4 - 11[1]	4.6	0	1.2	1.2	5.8	5.8
12 +[2]	2.0	0	1.0	.0	1.0	1.0
Oaks						
4 - 11	40.8	0	86.0	75.8	44.4	37.2
12 +	49.4	0	52.4	3.4	42.4	26.8
Other species						
4 - 11	35.4	0	8.8	7.8	19.8	19.2
12 +	1.6	0	1.4	.6	3.0	1.4
Totals by sizes						
4 - 11	80.8	0	96.0	84.8	70.0	62.2
12 +	53.0	0	54.8	4.0	46.4	29.2
Grand Total	133.8	0	150.8	88.8	116.4	91.4

[1] Includes trees from 3.6 to 11.5 inches d.b.h.
[2] Includes trees from 11.6 and larger in d.b.h.

Table 3.--Density of individuals per acre by species and groups
of species for topographic positions and degrees of cutting

(Number   per acre)

Degree of cutting and species	Ridge	Upper slope	Middle slope	Lower slope	Average for all slope positions[1]
Clear cut					
Yellow-poplar	6,150	5,750	5,958	7,393*[2]	6,340
All oaks	2,300	3,250	3,542	2,642	2,960
"Other" species	2,250	1,857	2,666	2,357	2,270
All species	10,700	10,857	12,166	12,392	11,570
Heavily cut					
Yellow-poplar	750**[3]	1,441**	4,500**	7,600**	3,020
All oaks	5,900	5,853	4,639	3,000**	5,140
"Other" species	950*	1,353	2,139	1,800	1,600
All species	7,600**	8,647*	11,278**	12,400**	9,760
Lightly cut					
Yellow-poplar	1,409	1,467	800*	1,375	1,180
All oaks	12,000**	9,466	9,200	1,875**	9,310
"Other" species	1,363**	1,600*	3,050**	3,625**	2,290
All species	14,772**	12,533	13,050	6,875**	12,780

1/ If slope position did not affect number of individuals found, the average number per acre should not differ from the average for all slope positions.

2/ *Significant differences between expected and actual number of individuals per acre. Odds are 19 against 1 that differences are due to chance rather than slope position.

3/ **Highly significant differences between expected and actual number of individuals per acre. Odds are 99 against 1 that differences are due to chance rather than slope position.

Table 4.--Frequency of reproduction by species and groups of species for topographic positions and degrees of cutting

(In percent)

Degree of cutting and species and species groups	Ridge	Upper slope	Middle slope	Lower slope	All positions
Clear cut					
At least one:					
Yellow-poplar	80	86	92	89	87
Oak	70	82	100	64	79
"Other"	85	61	83	85	78
Any species	100	100	100	100	100
Heavily cut					
At least one:					
Yellow-poplar	40	62	69	60	60
Oak	90	94	97	100	95
"Other"	60	70	75	60	70
Any species	90	100	100	100	98
Lightly cut					
At least one:					
Yellow-poplar	41	53	40	75	47
Oak	95	97	100	75	96
"Other"	64	73	87	88	78
Any species	100	100	100	88	99

Table 5.--Composition[1]/ of the original stands and the reproduction
for the three degrees of cutting

(In percent)

Species or groups	Clear cut		Heavily cut		Lightly cut	
	Original stand[2]/	Reproduction: seedlings and sprouts	Original stand	Reproduction: seedlings and sprouts	Original stand	Reproduction: seedlings and sprouts
Yellow-poplar	5	55	1	31	6	9
All oaks	67	25	92	53	74	73
Other species	28	20	7	16	20	18
Total	100	100	100	100	100	100
Total stems per acre	133.8	11,570	150.8	9,760	115.2	12,780

1/ Based on numbers of trees or seedlings, seedling sprouts, and sprout clumps.

2/ Includes all trees 3.6 inches d.b.h. and larger.

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Table 6.--Percent of cover for plants, obstructions,
and open area for three degrees of cutting

(In percent)

Species or category	:	Clear cut	:	Heavily cut	:	Lightly cut
	:			Cover		
Yellow-poplar		0.6		1.6		0.7
Oaks		3.4		13.9		13.0
"Other" trees		24.4		25.1		25.3
Shrubs[1]/		2.0		6.4		5.6
Herbs and vines[2]/		48.4		29.8		26.3
Obstructions		9.1		5.6		6.4
Open		12.1		17.6		22.7
Total		100.0		100.0		100.0

[1]/ Includes hawthorn, hazelnut, huckleberry, blueberry, New Jersey tea, and sumac (1).

[2]/ Includes approximately 85 species of herbaceous plants, grape, catbrier, and Virginia creeper (1).

Table 7.--Density of individuals per acre by species
and groups of species for north and south aspects
and degree of cutting

(Number per acre)

Degree of cutting and species	North aspect	South aspect	Average for all aspects
Clear cut			
Yellow-poplar	6,156	6,666	6,340
All oaks	3,500*[1]	2,000**[2]	2,960
"Other" species	1,844*	3,028**	2,270
All species	11,500	11,694	11,570
Heavily cut			
Yellow-poplar	4,717**	1,574**	3,020
All oaks	5,217	5,074	5,140
"Other" species	1,652	1,555	1,600
All species	11,586**	8,203**	9,760
Lightly cut			
Yellow-poplar	1,109	1,240	1,180
All oaks	7,739**	10,648**	9,310
"Other" species	2,391	2,204	2,290
All species	11,239**	14,092**	12,780

[1] *Significant differences between expected and actual number of individuals per acre. Odds are 19 against 1 that differences are due to chance rather than slope position.

[2] **Highly significant differences between expected and actual number of individuals per acre. Odds are 99 against 1 that differences are due to chance rather than slope position.

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Table 8.--Frequency of reproduction by species and groups

of species for aspects and degrees of cutting

(In percent)

Degree of cutting and species and species groups	Aspect		
	North-facing	South-facing	Both aspects
Clear cut			
At least one:			
Yellow-poplar	89	83	87
All oaks	83	72	79
"Other" species	72	89	78
Any species[1]	100	100	100
Heavily cut			
At least one:			
Yellow-poplar	93	31**[2]	60
All oaks	98	92	95
"Other" species	74	67	70
Any species	100	96	98
Lightly cut			
At least one:			
Yellow-poplar	43	50	47
All oaks	93	98	96
"Other" species	72	83	78
Any species	98	100	99

[1] *Significant differences between expected and actual number of individuals per acre. Odds are 19 against 1 that differences are due to chance rather than slope position.

[2] **Highly significant differences between expected and actual number of individuals per acre. Odds are 99 against 1 that differences are due to chance rather than slope position.

Table 9.--Distribution of quadrats by slope position
and aspect for the three degrees of cutting

Slope position and aspect	Degree of cutting		
	Clear cut	Heavily cut	Lightly cut
	Number	Number	Number
Ridge	20	20	22
Upper slope	28	34	30
Middle slope	24	36	40
Lower slope	28	10	8
Total	100	100	100
North	64	46	46
South	36	54	54
Total	100	100	100

Table 10.--Significance of difference in average density
of reproduction between degrees of cutting

Species or group	Between clear cut and heavily cut blocks	Between clear cut and lightly cut blocks	Between lightly cut and heavily cut blocks
Yellow-poplar	Highly significant[1]	Highly significant	Highly significant
All oaks	Highly significant	Highly significant	Highly significant
Other species	Highly significant	Non-significant[2]	Highly significant
Total	Highly significant	Significant[3]	Highly significant

1/ The probabilities are at least 100 against 1 that differences are due to chance.
2/ The probabilities are less than 20 against 1 that differences are due to chance.
3/ The probabilities are at least 20 against 1 that differences are due to chance.

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